

CLAIMS

1 1. An output stage for providing a substantially symmetrical rail-to-rail output
2 voltage, the output stage comprising:

3 a first field effect device having a first source, first drain, and first gate, the first
4 source being coupled to a power supply V_{CC} ;

5 a second field effect device complementary to the first field effect device, wherein the
6 second field effect device includes a second source, second drain, and second gate, and
7 wherein the second source is coupled to a power supply having a nominal voltage supply of
8 V_{EE} and wherein the second drain is coupled to the first drain; and

9 an output sink network coupled to the second gate, wherein the output sink network
10 drives the second field effect device such that a product of a first current in the first field
11 effect device and a second current in the second field effect device is substantially equal to a
12 predetermined constant.

1 2. An output stage as recited in claim 1, wherein a sum of the first current and
2 the second current is essentially equal to a predetermined constant during operation of the
3 output stage.

1 3. An output stage as recited in claim 1, wherein the first field effect device is
2 configured in a common source configuration.

1 4. An output stage as recited in claim 1, wherein the first field effect device is a
2 P-channel metal oxide semiconductor field effect (PMOS) transistor.

1 5. An output stage as recited in claim 4, wherein the second field effect device is
2 an N-channel metal oxide semiconductor field effect (NMOS) transistor.

1 6. An output stage as recited in claim 5, wherein the output sink network utilizes
2 a current mirror to track the current in the first field effect device.

1 7. An output stage as recited in claim 6, wherein the current mirror tracks the
2 current in the first field effect device at a predetermined ratio of the current in the first field.

1 8. An output stage as recited in claim 1, wherein the first field effect device is an
2 N-channel metal oxide semiconductor field effect (NMOS) transistor.

1 9. An output stage as recited in claim 8, wherein the second field effect device is
2 a P-channel metal oxide semiconductor field effect (PMOS) transistor.

1 10. An output stage as recited in claim 1, wherein a substantially rail-to-rail output
2 voltage produced by the output stage is no more than one V_{GS} and two V_{Dsat} from either rail.

1 11. A method for providing an output signal from an output stage of a low voltage
2 operation amplifier capable of providing a substantially rail-to-rail output voltage, the method
3 comprising the operations of:

4 providing an input signal to a first field effect device having a first source, first drain,
5 and first gate, the first source being coupled to a power supply V_{CC} ; and

6 driving a second complimentary field effect device utilizing an output sink network
7 such that a product of a first current in the first field effect device and a second current in the
8 second field effect device is substantially equal to a predetermined constant.

1 12. A method as recited in claim 11, wherein a sum of the first current and the
2 second current is essentially equal to a predetermined constant during operation of the
3 amplifier.

1 13. A method as recited in claim 11, wherein the first field effect device is
2 configured in a common source configuration.

1 14. A method as recited in claim 13, wherein the first field effect device is a P-
2 channel metal oxide semiconductor field effect (PMOS) transistor.

1 15. A method as recited in claim 14, wherein the second field effect device is an
2 N-channel metal oxide semiconductor field effect (NMOS) transistor.

1 16. A method as recited in claim 15, further comprising the operation of tracking
2 the current in the first field effect device utilizing a current mirror.

1 17. A method as recited in claim 16, wherein the current mirror tracks the current
2 in the first field effect device at a predetermined ratio.

1 18. A method as recited in claim 11, further comprising the operation of
2 producing an essentially rail-to-rail output voltage, the essentially rail-to-rail output voltage
3 being no more than one V_{GS} and two V_{Dsat} from either rail.

1 19. An application specific integrated circuit (ASIC) having an output stage for a
2 low voltage operational amplifier, the ASIC comprising:

3 a first field effect device having a first source, first drain, and first gate, the first
4 source being coupled to a power supply V_{CC} ;

5 a second field effect device complementary to the first field effect device, wherein the
6 second field effect device includes a second source, second drain, and second gate, and
7 wherein the second source is coupled to a power supply having a nominal voltage supply of
8 V_{EE} and wherein the second drain is coupled to the first drain; and

9 an output sink network coupled to the second gate, wherein the output sink network
10 drives the second field effect device such that a product of a first current in the first field
11 effect device and a second current in the second field effect device is essentially equal to a
12 predetermined constant during operation of the output stage.

1 20. An ASIC as recited in claim 19, wherein the first field effect device is
2 configured in a common source configuration.

1 21. An ASIC as recited in claim 19, wherein the first field effect device is a P-
2 channel metal oxide semiconductor field effect (PMOS) transistor.

1 22. An ASIC as recited in claim 21, wherein the second field effect device is an

2 N-channel metal oxide semiconductor field effect (NMOS) transistor.

1 23. An ASIC as recited in claim 22, wherein the output sink network utilizes a

2 current mirror to track the current in the first field effect device.

1 24. An ASIC as recited in claim 23, wherein the current mirror tracks the current

2 in the first field effect device at a predetermined ratio. A method as recited in claim 13,

3 wherein the current mirror tracks the current in the first field effect device at a predetermined

4 ratio.

1 25. An ASIC as recited in claim 24, wherein the predetermined ratio is about 6:1.

1 26. An ASIC as recited in claim 19, wherein a substantially rail-to-rail output

2 voltage produced by the output stage is no more than one V_{GS} and two V_{Dsat} from either rail.

1 27. An operational amplifier output stage suitable for low voltage operation and

2 capable of providing a substantially rail-to-rail output voltage, the output stage comprising:

3 a push-pull output network, wherein the push-pull output network receives a first

4 input signal and a second input signal, the first input signal being provided by an input signal

5 V_{IN} ; and

6 an output sink network, wherein the output sink network provides the second input

7 signal to the push-pull output network.

1 28. An operational amplifier output stage as recited in claim 27, wherein the push-

2 pull output network includes a first field effect device and a second complimentary field

3 effect device.

1 29. An operational amplifier output stage as recited in claim 28, wherein the first

2 field effect device is configured in a common source configuration.

1 30. An operational amplifier output stage as recited in claim 29, wherein the
2 output sink network utilizes a current mirror to track the current in the first field effect
3 device.

1 31. An operational amplifier output stage as recited in claim 30, wherein the
2 current mirror tracks the current in the first field effect device at a predetermined ratio.

1 32. An operational amplifier suitable for operating on low input voltages and
2 capable of providing a substantially symmetrical rail-to-rail output voltage, the operational
3 amplifier comprising:

4 an input stage; and

5 an output stage coupled to the input stage, wherein the output stage includes an output
6 sink network.

1 33. An operational amplifier as recited in claim 32, wherein the output stage
2 further includes a push-pull output network, wherein the push-pull output network receives a
3 first input signal and a second input signal, the first input signal being provided by an input
4 signal V_{IN} .

1 34. An operational amplifier as recited in claim 33, wherein the output sink
2 network provides the second input signal to the push-pull output network.